Field Campaign Resource Allocation Using Statistical Decision Analysis

Research Highlight

In many atmospheric science field campaigns, investigators are budgeted some number of flight hours to collect data under specific, imperfectly forecastable atmospheric conditions. In such field campaigns, investigators must assess atmospheric conditions each day and make a resource-allocation decision: are conditions good enough to use some of our scarce flight hours to fly our planes today, or would we be better off saving those flight hours for some future day? Optimal decision-making requires not only a consideration of atmospheric conditions but also a cost-benefit analysis involving expected future atmospheric conditions, the amount of flight hours available, and the amount of time left in the field campaign. Armed with model guidance and vast amounts of forecasting experience, investigators are typically well-trained to assess atmospheric conditions but may struggle to resolve the multi-dimensional decision problem.

Investigators in the Atmospheric Radiation Measurement (ARM) Climate Research Facility's Small Particles in Cirrus (SPARTICUS) field campaign sought to sample cirrus clouds over the ARM Southern Great Plains (SGP) site between January and June 2010. Resource allocation decisions during the SPARTICUS campaign were made using traditional heuristic methods. In parallel with the SPARTICUS team, investigators at Penn State University developed an algorithmic decision tool to make daily flight recommendations, seeking to maximize the number of flights undertaken under optimal conditions by the end of the field campaign.

Probabilistic forecasts of cloud conditions suitable for data collection were generated using relative humidity (RH) forecasts from the Global Forecast System (GFS). Using self-organizing maps, a historical set of RH profiles was represented by 24 characteristic RH profiles, each with an associated historical conditional probability of corresponding to optimal cloud conditions. An optimization procedure based on dynamic programming was then used to generate day-ahead fly/no-fly decisions for research flights over the SGP site. A post-experiment analysis demonstrated that the algorithmic decision tool would have delivered 11% more optimal data, while shortening the length of the campaign season by twenty-nine days and reducing the per-day expenditure of investigator time on activities of forecasting and decision-making.

Reference(s)

Hanlon CJ, JB Stefik, AA Small, J Verlinde, and GS Young. 2013. "Statistical decision analysis for flight decision support: The SPartICus campaign." Journal of Geophysical Research – Atmospheres, , . ACCEPTED.

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Cloud Life Cycle